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How is the Iranian Stock Market Affected by Geopolitical Risk and Economic Policy Uncertainty in China, the US, and Globally?

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Abstract

In the contemporary global economy, the interconnectedness of national markets has become increasingly pronounced. Over the past decade, Iran has experienced an annual average import of approximately $40 billion and exports of $38 billion, highlighting emerging cross-border economic linkages. These international connections mean that domestic factors within Iran's markets are now heavily influenced by external forces. This research investigates the impact of two types of uncertainty—geopolitical risk (GPR) and economic policy uncertainty (EPU)—originating from global, Chinese, and United States sources on the returns and volatility of the Iranian stock exchange. Monthly data from November 2008 to March 2024 were analyzed using a Generalized Additive Model (GAM). The results demonstrate that EPU from global and Chinese sources significantly nonlinearly affects the returns and volatility of the Iranian stock market. In contrast, EPU from the United States only impacts stock market volatility. GPR from China and globally has a direct linear effect on both returns and volatility. The combined effects of EPU and GPR from China and the US also significantly influence returns and volatility, while the simultaneous global effects only impact the returns of the Iranian stock exchange. The findings in the field of GPR indicate that when GPR occurs, investors in the Iranian stock market consider it a safe asset, and the occurrence of GPR serves as an incentive to enter the capital market in Iran. Conversely, the findings regarding EPU suggest that when investors perceive EPU from China, it leads to specific economic effects, prompting them to alter their portfolios. However, the recognition of EPU from the US and global sources is less pronounced among investors, leading them to prefer not to take action. These findings hold important implications for investors and stakeholders in the Iranian financial markets, providing insights that can inform investment strategies and policy decisions.

Keywords:
Economic Policy Uncertainty,
Geopolitical Risk,
Generalized Additive Model,
Stock Market Return

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1. Introduction

The past three decades have seen increased financial and real globalization in developed and developing economies worldwide. In financial markets, global integration is strengthened through the formation of free trade areas or currency unions, allowing economic shocks in certain countries or regions to be transmitted to the rest of the world. In a situation where economies are increasingly integrated into the global economy, even if an economy chooses not to adopt a globalization policy, it will still be affected by the global economy. It brings limited economies; today, the global economy is interconnected through trade and financial flows. Uncertainty in a leading economy, such as China and the United States, is not confined within its borders and can spread to the rest of the world. For this reason, a recently growing body of literature has examined international uncertainty spillovers (Berger et al., 2017; Carrière-Swallow and Céspedes, 2013; Gabauer and Gupta, 2018; Gupta et al., 2016; Kamber et al., 2016; Trung, 2019; Yin and Han, 2014) .In the meantime, various studies have examined the relationship between uncertainty in a large and global economy such as the United States and China on stock returns in foreign markets (Christou et al., 2017; Hu et al., 2018; Ko and Lee, 2015; Phan et al., 2018) . In these studies, the uncertainties of the origin countries are used to predict the market returns of other countries. The results mainly show that these spillovers have a negative effect on the stock returns of the destination country. However, both the theoretical and empirical literature ignore that relationships may change when political and economic relationships are complex. There are various types of risk and uncertainty in both domestic and foreign countries, and investors include stocks from other countries in their asset portfolio to optimise portfolio management.

The literature shows that the choice of a foreign country is based on the level of risk and uncertainty in that country; the total of this portfolio management of domestic and foreign country stocks has led to the expansion of international capital flows in the world stock markets. International portfolio diversification and foreign direct investment are among the main drivers of stock market integration(Andrikopoulos et al., 2023; Babaei et al., 2023) .With the increase of the conflict between the gears of the international economy and the globalization of the economy, the influence of the linkage of the global financial markets has increased. While there has been a significant increase in the correlation between stocks around the world (Mensi et al., 2023), the spillover between uncertainties and Different financial markets has also increased in different countries (Jiang and Ye, 2022), any GPR and uncertainty can be immediately received by international investors and automatically lead to structural changes in the price and volatility of assets (Belcaid and El Ghini, 2019), uncertainties are the main obstacle to the growth of financial markets (Uddin et al., 2021) and cause the stagnation in financial markets to intensify (Tsai, 2017).

Literature also shows that uncertainty has adverse effects on financial activities and company value (Boutchkova et al., 2012; Brogaard and Detzel, 2015; Pastor and Veronesi, 2012; Pástor and Veronesi, 2013). Although the origin of theoretical literature entering the field of uncertainty and financial market is relatively old and it can be seen Markowits (1952), Roy (1952), and Tobin (1958) as the pioneers of this field, considering that nowadays, unfortunately, "black swan events" which are the source of increasing uncertainty in the global economy, occur frequently and affect economic activities and financial markets (Dong et al., 2023; Wei et al., 2022) ،the attention to uncertainty and its criteria, as well as the impact on economic activities and financial markets, has again been the focus of researchers (Baker et al., 2016; Basu and Bundick, 2017; Bekaert et al., 2013; Bloom, 2009; Jurado et al., 2015; Lahiri and Sheng, 2010; Leduc and Liu, 2016; Orlik and

Veldkamp, 2014).

There are various indices to show uncertainty; in the existing literature, mainly two indices are used to show uncertainties: a) geopolitical risk index (GPR) introduced by Caldara and Iacoviello (2022), b) economic policy uncertainty index (EPU) by Baker et al. (2016) has been introduced.

GPR is defined as:" the risk associated with wars, terrorist acts, and tensions between states that affect the normal course of domestic politics and international relations "(Caldara and Iacoviello, 2022), and events such as the US presidential election, the US-China trade war, Brexit, the recent war in Ukraine, nuclear threats and recent tensions in the Middle East all fall under the heading of GPR (Fiorillo et al., 2023).

The impact of geopolitical uncertainty on oil (Bouoiyour et al., 2019), precious metals (Baur and Smales, 2020), commodity market (Ramiah et al., 2019), and cryptocurrencies (Bouri and Gupta, 2021) has been investigated. Still, the literature Related to geopolitical uncertainty and the stock market, especially in the GPR influence of other countries, has been relatively neglected.

The EPU is defined as uncertainty regarding financial, regulatory or monetary policy (Brogaard and Detzel, 2015) and refers to the contributions of policymakers to create uncertainty (Baker et al., 2016). This EPU reflects the development of pessimistic expectations(Arouri et al., 2016; Guo et al., 2018) and refers to a variety of macroeconomic policy uncertainties, including uncertainty of policy expectations, uncertainty of policy implementation, and the possibility of changing the position of government policies, particularly at the financial, monetary and regulatory levels (Gulen and Ion, 2016; Le and Zak, 2006), EPU refers to the inability of market participants to predict policy and economic decisions made by governments (Lean et al., 2024) and we define and explain EPU as follows: a phenomenon that has the nature of information asymmetry and refers to information gaps between politicians and other economic factors, which are largely concerned with monetary and fiscal policy.

The basis of the distinction between EPU and GPR lies in the fact that EPU depicts uncertainty about the real economy. At the same time, GPR represents the risk components related to war and war situations; GPR is not linked to the business cycle and has no economic basis (Fiorillo et al., 2023). The argument for the necessity of using EPU and GPR and their effects on the stock market is presented by Kannadhasan and Das (2020) with emphasis on data extraction methodology: The EPU index is estimated using a text mining method from the outputs of 10 leading newspapers using important terms of economic events, such as "monetary policy, fiscal policy, taxation", etc., but the GPR is estimated using the outputs of 11 newspapers. Information related to geopolitical tensions such as "terrorism", "military conflicts", "political tensions", "communal disharmony" and other cases are used, and there are fundamental differences in the estimation and nature of these indicators. Dong et al. (2023) also state that the correlation between GPR and EPU indices is very small and proves that these two indices show risk and uncertainty from different perspectives; the behavioral decisions of investors are likely to be different when faced with different risks. The existing empirical literature on the impact of GPR and EPU uncertainty on the financial market is severely limited.

This study has six contributions: 1) Examines the impact of GPR and EPU with three sources in China, the US and the global[1] on stock market volatility; 2- The case study is Iran's financial market. 3 As a robustness check in addition to stock market volatility, the effects on stock market returns are also examined; 4- Linear or nonlinear effects are examined and tested, 5- Impact of

1 . A total of six uncertainties are examined, global GPR, U.S. GPR, GPR, GLOBAL EPU, US EPU and China EPU

coefficients, with attention to different values of independent variables (uncertainties), is separately investigated, 6. The simultaneous relationship of two uncertainties[1] on the stock market is investigated.

The other parts of the paper are organized as follows: In Part 2, the literature related to the subject is discussed; in Part 3 the Generalized additive model (GAM) is presented, and while introducing the data reference, a brief explanation is provided about them, in Part 4, model estimation and results are presented, for this purpose a table of results and a significant review are presented, followed by smooth function monovariate diagrams (Represents beta changes per change in the values of the independent variable) and bivariate variables (indicating changes in dependent variable for simultaneous changes in two independent variables) are presented and in Part 5, while summarizing and presenting the results briefly, suggestions are presented.

2. Literature and theoretical foundations

2.1 Risk spillover channels originating from foreign countries

Today, international economics has become more interrelated due to the expansion of global trade and the increase in foreign investment, resulting in a significant increase in the correlation between stocks around the world (Mensi et al., 2023) and the spread of economies to each other can be studied through the risk and uncertainty of one country to another(Liang et al., 2020). The current state of the world, recent economic and political events, such as the ongoing U.S.-China trade conflict, and general emergencies, such as the COVID-19 outbreak, have increased uncertainty, market volatility following the Russian president's decision to invade Ukraine, Britain's vote to leave the European Union, and the U.S. presidential election in 2016 and 2020, there are examples of how political uncertainty in one country can affect companies and stock markets in other countries (Fulgence et al., 2023) and turn uncertainties into a topic of interest for policymakers, investors and academics, as it is argued that uncertainties are the cause of investment risks(Amore and Corina, 2021; Cao et al., 2019)

Among countries, the role of the United States economy has a special place; the United States is the largest economy on the planet, has about one-fifth of global production, energy demand, foreign direct investment (FDI), and has one-tenth of global trade and one-third of Stock market value (Balli et al., 2021). Since the United States has the world's largest stock market, early tremors in the U.S. economy and financial markets are not limited to the U.S. but also spread to other countries, the financial crisis of 2008 has shown that the US stock market crash can be moved to other countries at an astonishing rate, eventually leading to a global crisis (Su et al., 2019) and stock markets can receive the spillover effects of uncertainty from other countries (Belcaid and El Ghini, 2019; Boako and Alagidede, 2018), on the other hand, the financial investment of the United States in other countries has increased, and this issue has caused the transfer of risk to the financial markets of the world countries, therefore, the uncertainty is transferred to the financial markets (Balli et al., 2021) also, the United States always tries to attract many international investors, as a result, large international investors invest in the stock market of the United States and their own country, so the uncertainty related to the United States in addition to having an effect on The stock market of this country is also transferred to the country of origin through foreign investors (Jiang et al., 2023) in fact, the risk and uncertainty for a company does not depend solely on the location of its production and location, but also on the location where the company is located (Ardelean et al., 2017). Jiang et al. (2023) state the mechanism of this transition as follows: US uncertainty affects international stock returns through the cash flow channel and the discount rate.

1 . China EPU and GPR, EPU & GPR World, U.S. EPU & GPR

Examining the customs data of the Islamic Republic of Iran shows that, on average, in the last 10 years, Iran has annually imported about 40 thousand million dollars and exported 38 thousand million dollars. China's share has been about 26% of imports and 23% of exports. Therefore, China's uncertainties can spill over into Iran's conditions. Considering the significant proportion of China in Iran's exports and imports, China's supply and demand affect Iran's economy, as Miller and Temurshoev (2017) consider cross-border supply and demand as a driver of production in countries. Therefore, Iran is sensitive to the uncertainty shocks of China, and this sensitivity also affects the stock market.

According to the existing literature, uncertainty with external origin significantly impacts stocks.

2.2 GPR and the stock market

2.2.1 Channels of influence of GPR on the stock market

Theoretically, the communication channels between GPR and the stock market can be presented in different categories.

GPR and Productivity Change: Geopolitical uncertainty hampers the proper development of financial markets, leading to inefficiencies (Ding et al., 2022), which can impact the stock market.

GPR and Production Reduction: Geopolitical uncertainty often correlates with temporary halts in production. For instance, Bloom (2009) notes that events like the Cuban Missile Crisis, JFK's assassination, OPEC oil price shocks, and the 9/11 terrorist attacks increase uncertainty and cause firms to hold back on investments and hiring in the short term. Saint Akadiri et al. (2020) demonstrate that rising geopolitical uncertainty significantly hampers short-term and long-term economic growth, reducing production flow's influence on the stock market.

GPR and Corporate Investment: GPR plays a crucial role in investment decisions. Higher GPR increases the risk of investing in financial markets, prompting investors to exit and seek safer financial instruments (Zhang et al., 2023). GPR affects corporate investment in two ways: first, it reduces overall investment (Wang et al., 2019), and second, it delays the decision-making process of market participants, causing delays in companies' investment activities (Salisu et al., 2022). Thus, GPR can have an impact on the stock market.

GPR and Innovation (Technological Improvement): GPR negatively affects R&D investment (Pan, 2019), but it can stimulate innovation in certain companies, especially state-owned or government-subsidized firms (Jia et al., 2022). Yu and Wang (2023) examine the impact of geopolitical uncertainty and foreign direct investment (FDI) in 41 countries from 2003 to 2020, revealing that geopolitical uncertainty can hinder FDI inflows and impede innovation spillover. The relationship between FDI and stock returns is also positive and significant (Haq, 2019) ،Additionally, an increase in GPR can reduce global trade and investment, resulting in a decrease in the globalization index, Consequently, while raising financing costs for companies, GPR inhibits technology transfer, weakens innovation, and affects company stocks.

GPR and Energy Prices: Recent years have witnessed significant volatility in global oil prices due to natural disasters, economic crises, geopolitical conflicts, and terrorist attacks (Sheng et al., 2020; Silvennoinen and Thorp, 2013). Understanding the key determinants of oil prices is crucial for decision-makers in investment, consumption, production, risk management, and policy formulation (Xu et al., 2021). Geopolitical tensions, including civil wars, terrorism, and armed conflicts, have been closely associated with oil price dynamics (Hu et al., 2020). Su et al. (2021) investigate the relationship between oil prices and geopolitical uncertainty, finding that an increase in geopolitical uncertainty (e.g., war) leads to higher oil prices. Still, decreasing geopolitical uncertainty does not necessarily result in lower oil prices. They further suggest that the price of oil

itself can contribute to an increase in geopolitical uncertainty, highlighting its political characteristics. However, different studies present varied results. While some find a positive and significant impact of geopolitical uncertainty on oil prices, especially before 2000 (Noguera-Santaella, 2016), others show insignificant effects(Bouoiyour et al., 2019; Monge et al., 2017) or limited impact due to OPEC's ability to adjust production capacity and oil reserves(Selmi et al., 2020) .Overall, GPR's influence on oil prices can affect production and subsequently impact the stock market, considering oil's significance as a production input**.**

2.2.2 Studies in the field of GPR and stock market

The literature on the relationship between GPR and the stock market can be divided into three categories: the effect of GPR on stock market returns, the effect of GPR on stock market volatility, and the effect of GPR on stock market returns and volatility.

The connection between Geopolitical Risk (GPR) and stock market return: Arfaoui and Naoui (2022) found that terrorist attacks rapidly reduce stock market returns in the UK and France. Balcilar et al. (2018) examined the impact of GPR on returns and volatility in BRICS stock markets and observed that these markets do not uniformly react to GPRs. Instead, GPRs tend to affect stock market volatility rather than returns. Rawat and Arif (2018) investigated the effects of geopolitical shocks on stock market returns in BRIC economies and discovered that the impact of GPR on stock returns varies across countries, with Brazilian and Russian funds showing more sensitivity compared to Indian and Chinese funds. However, some studies argue against a consistent negative impact of GPR on returns and stock prices. For example, Ramiah et al. (2010) suggest that the perceived cost of terrorist attacks may not always be accurately reflected in stock market reactions. Cam (2008) proposes that in conditions of heightened GPRs, sectors such as defense, water, and communication may experience increased demand, potentially leading to higher stock prices in those sectors. Ma et al. (2022) investigated the effect of GPR on stock return prediction and found that the Geopolitical Threats Index (GPRHT) can help forecast stock returns.

The association between GPR and stock market volatility: Salisu et al. (2022) examined the relationship between GPR and stock market volatility in emerging economies, revealing that GPRs increase stock market volatility. They also noted that the GPR index related to actionable threats has a stronger impact than the GPR index related to affective threats. Bouras et al. (2019) studied the role of individual country and global GPRs on stock market returns and volatility in 18 emerging economies, finding that country-specific GPRs affect neither returns nor volatility significantly. However, when considering a broad measure of global GPR, the effect on volatility is economically and statistically robust, whereas the effect on returns is not significant. Ndako et al. (2021) investigated the impact of GPR on the volatility of Islamic stock returns in Indonesia and Malaysia, discovering that GPR increases volatility in both countries, with a greater impact observed in Indonesia. Additional analysis in their study demonstrates that incorporating GPR data improves the prediction of volatility in Islamic stock returns. Chiang (2021) asserts that GPRs cause significant volatility in the global economy, particularly in financial markets, making them crucial factors for investment decisions and portfolio selection to safeguard asset values. Zhang et al. (2023) examined the relationship between GPR and global stock market volatility, finding a positive and significant effect of GPR on stock market volatility. They also observed that the impact of GPR on stock market volatility is higher in emerging economies, crude oil exporters, and peaceful countries.

The relationship between GPR and stock market returns and volatility: Apergis et al. (2018)

discovered that GPR can predict the volatility of 50% of these companies but cannot predict their returns. Based on the existing empirical literature, there appears to be a significant relationship between GPR and stock market returns and volatility.

2.3 EPU and the Stock Market

The relationship between EPU and the stock market can be divided into two categories: from the perspective of companies and from the perspective of investors.

From the point of view of companies: according to Bloom (2009), a sudden increase in economic uncertainty disrupts the prospects of business and household consumption and leads to a decrease in future cash flows compared to the level predicted by companies, and in turn, causes a decrease in company performance and reducing stock returns.

From the point of view of investors, the increase in uncertainties makes investors move the decision-making to the future period; on the other hand, according to the argument of Bali et al. (2017), in the face of a sudden increase in economic uncertainty, investors turn to assets that they believe will increase their returns during times of economic uncertainty to protect against asset declines. This suggests that investors are willing to hold stocks with higher covariance with economic uncertainty. In doing so, they are willing to pay higher prices and accept lower returns for stocks with greater uncertainty. These changes in assets cause changes in asset returns.

Mei et al. (2018) studied the impact of the US Economic Policy Uncertainty (EPU) on the European stock market. The findings indicate that the US EPU can influence the prediction of European stocks. However, the European EPU index itself does not significantly enhance forecast accuracy. Su et al. (2019) employed a bivariate GARCH-MIDAS model to examine the influence of US EPU on stock market volatility in six industrialized countries (Germany, France, the UK, Japan, Italy, and Canada) and three emerging countries (China, India, and Russia). They found a positive correlation between US EPU and stock market volatility in these countries. Dakhlaoui and Aloui (2016) analyzed the interaction between US economic policy uncertainty and BRIC stock markets. Their results revealed a time-varying correlation between US economic uncertainty and stock market volatility, which fluctuates during periods of global economic instability. Christou et al. (2017) employed a panel VAR model for Australia, Canada, China, Japan, South Korea, and the United States from January 1998 to December 2014. They discovered that an increase in US EPU negatively impacts stock returns in all countries except Australia. Additionally, each country's EPU has a negative effect on its own stock returns. Tsai (2017) investigated the effect of EPU in four countries or regions (China, Japan, Europe, and the United States) on the stock returns of 22 markets worldwide. The results indicate that China's EPU has the most significant influence and exhibits contagion risk in various regional markets, except for Europe. The effect of US EPU is weaker than that of China, with Japan's EPU only affecting contagion risk in emerging markets. The European financial market is not affected by EPU.

2.4 EPU and GPR on the stock market

Kannadhasan and Das (2020) conducted a study to examine the influence of economic policy uncertainty (EPU) and geopolitical risk (GPR) shocks on the stock markets of emerging Asian economies using a quantile regression model. The findings indicate that EPU has a consistently negative relationship across all quantiles. At the same time, GPR exhibits a negative relationship in the lower quantiles and a positive relationship in the middle and upper quantiles (with EPU having a stronger impact on reducing asset prices compared to GPR). Furthermore, the negative effect of

EPU is stronger than the negative effect of GPR, and the dependence of stock returns on EPU and GPR exhibits asymmetric behavior. Zhang et al. (2023) explored the impact of global economic uncertainty measures on stock market volatility in China and found that the global economic policy uncertainty index, GPR index, and global economic condition index significantly affect the long-term volatility of China's stock market. Dong et al. (2023) investigated the impact of geopolitical, economic, and climate policy uncertainties (CPU, EPU, GPR, respectively) on the correlation between conventional stock markets and long-term energy stocks, as well as the correlation between conventional bonds and green bonds. They discovered that all three uncertainties lead to changes in the correlation between conventional and energy stocks. Additionally, when EPU and CPU levels are high, green bonds outperform conventional bonds, while the effects of GPR changes influence the superiority of each type of bond. Das et al. (2019) studied the effects of international economic policy uncertainty, GPR, and financial stress on the stock markets of 24 emerging economies using monthly data from January 1997 to May 2018. The results indicate heterogeneity in causality and severity of the shocks, with EPU having a greater impact than GPR and financial stress (FS). Khraiche et al. (2023) examined the impact of GPR on stock market development in a sample of 37 countries from 1975 to 2019. They found that the effects of GPR on stock market development vary across countries, with a stronger negative effect observed in North America and Europe compared to Asia. Additionally, the impact of GPR is greater in economies with higher levels of investment. Based on the existing literature, it is evident that GPR and EPU originating from outside regions such as America, China, and the world have a significant impact on the European stock market.

According to the existing literature, it seems that GPR and EPU originating from outside the region (United States, China and the world) significantly impact the Iranian stock market.

3. Methodology and model

3.1 Methodology

In classical econometric models, the relationship between independent and dependent variables is mainly considered to be linear, an assumption that may not always be maintained or may change in certain circumstances. One of the models that assume the linearity of the relationship as The basic assumption is not considered the Generalized additive model (GAM) (Wood, 2006a)

The advantage of this model over other nonlinear models is in not determining the default for the relationship between dependent and independent variables, and the model itself provides the form of the relationship function; another unique advantage of the GAM model is to examine the interaction of several variables. It is independent and simultaneous.

In GAM, the relationship curve between independent and dependent variables (smoothing function (f)) is estimated through splines(Wood et al., 2015)

To specify the location of notes and prevent excessive smoothing of splines in GAM, a roughness penalty term is added to the error So that the smoother the smoothing function is, the compensation term decreases and vice versa (Wood and Augustin, 2002)

The family of GAM models was introduced in 1987 by Hastie and Tibshirani (1987); in 1995, Hastie and Tibshirani (1995) pointed out the applications of GAM models in medical research, including the Cox model, in an article.

The tensor product is one of the important splines in estimating the multivariate smoothing function. The application of this spline in GAM was first introduced in 2006 by Wood (2006b)**.** This spline is used when the independent variables are not the same and the results do not change by changing the scale of one variable.

The GAM model is generally defined as follows:

$$g(\pi_i) = \beta X_i + s_1(x_{i,1}) + s_2(x_{i,2}) + ti_3(x_{i,3}, x_{i,4}) + \cdots$$

Where function f is called the smooth function.

Smooth function is generally obtained as follows:

$$s(x) = \sum_{j=1}^{k} \beta_j \times b_j(x)$$

In the above relation, $\beta_j$is a constant and unknown value, b_j is the known basic function.

To control the amount of smoothing, the term roughness penalty (J) is added to the logarithm of likelihood as follows.

$$\boldsymbol{l} = L(\theta|Y) - \frac{1}{2}(\lambda_1 J(s_1) + \lambda_2 J(s_2) + \lambda_3 J(ti_3) + \cdots)$$

The cubic spline to estimate the smoothing function is defined as follows:

$$s_t(t) = \sum_i \delta_i |t - t_i|^3 + b_1 + b_2 t$$

Parameters δ_i،b_1 & b_2 are fixed and uncertain numbers that are estimated by considering the relations $\sum_{\boldsymbol{i}} \delta_i = \sum_{\boldsymbol{i}} \delta_i t_i = 0$

The roughness penalty in this smoothing function is defined as follows.

$$J_t(s_t) = \int \left[\frac{ds_t^2(t)}{dt}\right]^2 dt$$

The smoothing function of two variables $f_{p\&q}(p_i, q_i)$ is estimated with the help of a tensor product spline. Suppose the marginal smoothers are defined as follows:

$$s_p(p) = \sum_{l_1=1}^{L_1} \delta_{l_l} \times b_{l_l}(p)$$

$$s_q(q) = \sum_{l_2=1}^{L_2} \delta_{l_2} \times b_{l_2}(q)$$

The functions b_{l_l} and $b_{l_2}$are certain basic functions. δ_{l_l} and δ_{l_2} are fixed and unknown coefficients. A cubic spline can be considered for edge smoothing.

The joint smoother is defined as follows:

$$ti_{p,q}(p,q) = \sum_{l_1=1}^{L_1} \sum_{l_2=1}^{L_2} \delta_{l_1,l_2} \times b_{l_l}(p) \times b_{l_2}(q)$$

Suppose we define the conditional smoothing function as follows.

$$s_{p|q=y}(x) = \sum_{l_1=1}^{L_1} \delta_{l_l}(y) \times b_{l_l}(p)$$

Then, the roughness penalty of the smoothing function is defined as follows.

$$J(ti_{p,q}) = \lambda_q \times \sum_{p=1}^{L_1} J(s_{q|p}) + \lambda_p \times \sum_{q=1}^{L_2} J(s_{p|q})$$

$\lambda_p$and $\lambda_q$parameters are smoothing control parameters in the p and q direction.

3.2. Model

According to the research literature, the model of this research is suggested as follows:

model1: $TEPIX_Return_t = s_1(\text{EPU}_{\text{Global}_t}) + s_2(EPU_{China_t}) + s_3(\text{EPU}_{US_t}) + s_4(GPR_t) + s_5(GPR_{CHINA_t}) + s_6(GPR_{US_t}) + ti_{1\&4}(\text{EPU}_{\text{Global}_t}, GPR_t) + ti_{2\&5}(EPU_{China_t}, GPR_{CHINA_t}) + ti_{3\&6}(\text{EPU}_{US_t}, GPR_{US_t}) + \varepsilon_t$

model2: $TEPIX_Volatility_t = s_1(\text{EPU}_{\text{Global}_t}) + s_2(EPU_{China_t}) + s_3(\text{EPU}_{US_t}) + s_4(GPR_t) + s_5(GPR_{CHINA_t}) + s_6(GPR_{US_t}) + ti_{1\&4}(\text{EPU}_{\text{Global}_t}, GPR_t) + ti_{2\&5}(EPU_{China_t}, GPR_{CHINA_t}) + ti_{3\&6}(\text{EPU}_{US_t}, GPR_{US_t}) + \varepsilon_t$

The data has been used monthly from November 2008 to March 2024, Where t is the time (month), Independent variables are explained in Table 1 and dependent variables in Table 2

Table 1. Independent variables

Variable	explanation	Source	Provider
EPU_Global_	economic policy uncertainty in the global. The EPU Index is a GDP-weighted average of national EPU indices for 21 countries: Australia, Brazil, Canada, Chile, China, Colombia, France, Germany, Greece, India, Ireland, Italy, Japan, Mexico, the Netherlands, Russia, South Korea, Spain, Sweden, the United Kingdom, and the United States.	http://www.policyuncertainty.com/gpr.html	(Baker et al., 2016)
EPU_China_	economic policy uncertainty in China. To measure economic policy uncertainty in China, we construct a scaled frequency count of articles about policy-related economic uncertainty in the South China Morning Post (SCMP), Hong Kong's leading English-language newspaper. The method follows our news-based indexes of economic policy uncertainty for the United States and other countries.	http://www.policyuncertainty.com/gpr.html	(Baker et al., 2013)
EPU_US_	economic policy uncertainty in the US. The monthly news-based Economic Policy Uncertainty Index is based on newspaper archives from Access World News's NewsBank service. The NewsBank Access World News database contains the archives of thousands of newspapers and other news sources from across the globe. While NewsBank has a wide range of news sources, from newspapers to magazines to newswire services, we conduct our analysis only utilizing newspaper sources.	http://www.policyuncertainty.com/gpr.html	(Baker et al., 2016)
GPR	GPR in the global. The Caldara and Iacoviello GPR index reflects automated text-search results of the electronic archives of 10 newspapers: Chicago Tribune, the Daily Telegraph, Financial Times, The Globe and Mail, The Guardian, the Los Angeles Times, The New York Times, USA Today, The Wall Street Journal, and The Washington Post. Caldara and Iacoviello calculate the index by counting the number of articles related to adverse geopolitical events in each newspaper for each month (as a share of the total number of news articles)	https://www.matteoiacoviello.com/gpr.htm	(Caldara and Iacoviello, 2022)
GPR_CHINA_	GPR in China	https://www.matteoiacoviello.com/gpr.htm	(Baker et al., 2016)
GPR_US_	GPR in US	https://www.matteoiacoviello.com/gpr.htm	(Baker et al., 2016)

According to Table (1), independent variables are used in this article; the other three independent variables mentioned in the model show the simultaneous effect of two independent variables. Table (2) describes the dependent variables.

Table2. Dependent variables

model	Variable	explanation	Source
1	TEPIX_Return	Monthly returns of the Iranian stock market	www.tsetmc.com
2	TEPIX_Volatility	Monthly volatility of the Iranian stock market	www.tsetmc.com

The lowest value of EPU_CHINA is in M2-2011 and the highest value is in M6-2019. The lowest value of EPU_GLOBAL is in M6-2014 and the highest value is in M5-2020, and finally the lowest value of EPU_USA is in M8-2014 and the highest value is in M5-2020.

The lowest value of GPR corresponds to M7-2021 and the highest value corresponds to M3-2022, the lowest value of GPR_CHINA corresponds to M5-2011 and the highest value corresponds to M3-2022 and finally the lowest value of GPR_USA corresponds to M7-2021 and Most of it is related to M3-2022.

The highest value of TEPIX_RETURN occurred during 2020-M7 and the lowest value was in 2021-M1. The highest value of TEPIX_VOLATILITY was M7-2020 and the lowest value was M6-2015.

According to Table (2) and the explanations provided, a total of 2 models have been fitted; firstly, the uncertainties on the monthly returns of the Iranian stock market are fitted and presented in parts 1-4, then in parts 2-4. The effects on the monthly volatility of the Iranian stock market are presented:

4. Results and robustness

4.1 Descriptive Statistics

Empirical results (The impact of uncertainties on the monthly returns of the Iranian stock market).

In order to familiarize ourselves with the values of the variables, we used descriptive statistics, and the results are presented in Table (3).

Table 3. Descriptive Statistics

	Mean	Median	Maximum	Minimum	Std. Dev.	Skewness	Kurtosis
EPU_CHINA_	300.810	229.860	852.050	59.440	187.930	0.660	2.270
EPU_GLOBAL_	184.080	166.120	431.560	86.350	72.200	0.770	2.910
EPU_US_	159.320	146.940	503.960	63.880	66.350	2.070	9.260
GPR	98.060	90.630	318.950	58.420	29.800	3.150	20.040
GPR_CHINA_	0.650	0.590	2.470	0.210	0.340	1.420	6.860
GPR_USA_	2.220	2.040	6.900	1.250	0.710	2.340	13.120
TEPIX_RETURN	0.030	0.020	0.450	-0.140	0.080	1.780	8.850
TEPIX_VOLATILITY	0.060	0.040	0.450	0.000	0.070	2.910	14.860

Source: research calculations

Descriptive statistics of the research data, including information about the average, median,

minimum, maximum, and standard deviation and skewness of the data, can be seen in Table (3); the above results were extracted from the monthly data review from November 2008 to March 2024. The descriptive statistics analysis shows that the section related to economic policy uncertainty, EPU_CHINA, has values between 59 and 852 and an average value of 300 units. EPU_GLOBAL has values between 86 and 431, with an average of 184. EPU_US ranges from 63 to 503 and usually has an average value of 159.

Also, in the data related to geopolitical uncertainty, GPR fluctuates between 58 and 318, and its average is 98; GPR_CHINA fluctuates between 0.21 and 2.47, and its average is 0.65, and finally, GPR_USA ranges from 1.25 to It fluctuates 6.90 and its average is 2.22.

The data related to the dependent variable shows that TEPIX_RETURN has fluctuated between -0.14 and 0.45, the average monthly return in the period under review was equal to 0.03, and TEPIX_VOLATILITY was between 0 and 0.45 and On average, monthly fluctuations were equal to 0.06.

4.2 Stationary test variables

For stationary test variables in this study, the unit root test of Dickey–Fuller (ADF) is used, and the results are presented in Table (4). According to Table (4), all the variables in levels are stationary, and the confidence level of all the variables is 1%.

Table 4. Stationary test variables

Variable name	Dickey–Fuller test	Critical values at the level of 1%	Critical values at the level of 5%	Critical values at the level of 10%	Stationary or non-stationary	Degree of integration
EPU_CHINA_	-4.160	-3.460	-2.870	-2.570	Stationary	I(0)
EPU_GLOBAL_	-3.560	-3.460	-2.870	-2.570	Stationary	I(0)
EPU_US_	-5.120	-3.460	-2.870	-2.570	Stationary	I(0)
GPR	-6.110	-3.460	-2.870	-2.570	Stationary	I(0)
GPR_CHINA_	-3.870	-3.460	-2.870	-2.570	Stationary	I(0)
GPR_USA_	-3.680	-3.460	-2.870	-2.570	Stationary	I(0)
TEPIX_RETURN	-3.880	-3.460	-2.870	-2.570	Stationary	I(0)
TEPIX_VOLATILITY	-4.950	-3.460	-2.870	-2.570	Stationary	I(0)

Source: research calculations

The estimation results are presented in Table (5):

According to the research findings in Table (5), EPU_Global and EPU_China significantly affect the return of the Iranian stock market. According to the edf statistics, this effect is nonlinear. The findings show that EPU_US does not significantly affect the return of the Iranian stock exchange. The triple findings related to GPR also show that GPR and GPR_CHINA have a significant effect on the return of Iranian securities, but GPR_USA does not have a significant effect. The effects of GPR are linear according to the level of edf. Finally, the significance analysis of two types of simultaneous uncertainty with the same origin shows that EPU and GPR significantly affect all three sources of China, the United States, and the Global. According to the edf statistic, simultaneous uncertainty with the origin of China and the United States has a nonlinear relationship; the findings of the research show the necessity of simultaneous investigations, considering that the possibility of identifying simultaneous effects can only be identified through the GAM model, the results show It shows that it is necessary to pay attention to simultaneous

effects. According to the findings, EPU and GPR related to the United States do not have a significant role individually, but the simultaneous examination of the two has a significant role.

Table (5) shows each variable's significance and the linear or nonlinear relationship. A smooth function was used to show the effects, and only the graphs whose significance was confirmed according to Table (5) were presented. First, the Smooth function related to single variables is presented in Figure 1:

Table 5. Estimation results of the model1; SE stands for the standard error of the parameter estimate. ‘‘edf’’ represents the effective degrees of freedom of the functional parameters and Ref. df is the Reference degrees of freedom

Parametric coefficients					
	Estimate	**SE**	**t value**	**p-value**	
(Intercept)	0.020	0.011	1.788	0.075	.
Approximate significance of smooth terms					
	edf	**Ref.df**	**F**	**p-value**	
s(EPU_Global_)	7.768	8.577	2.406	0.010	*
s(EPU_China_)	7.932	8.655	4.251	0.000	***
s(EPU_US_)	1.000	1.000	1.288	0.250	
s(GPR)	1.000	1.000	3.836	0.050	.
s(GPR_CHINA_)	1.000	1.000	4.591	0.030	*
s(GPR_USA_)	1.000	1.000	1.162	0.390	
ti(EPU_Global_,GPR)	1.000	1.000	2.878	0.090	.
ti(EPU_China_,GPR_CHINA_)	2.386	2.777	5.734	0.000	**
ti(EPU_US_,GPR_USA_)	5.570	6.972	4.095	0.000	***
Signif. codes: 0.000 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’					
R-sq.(adj)	0.452		Deviance explained	54.6%	
Durbin-Watson stat	1.65				

Source: research calculations

According to Figure 1, a Smooth function related to four single and significant variables is drawn .According to the methodology presented in part 3, in the single-variable Smooth function, the horizontal axis shows the values related to the independent variable and the vertical axis shows the influence of the dependent variable on the changes of the independent variable .In the top left figure, the effectiveness of the return of the Iranian stock market from EPU-Global is shown. According to the figure, global economic policy uncertainties up to values of 300 units in EPU_Global cause a decrease in the return of the Iranian Stock Exchange; for values greater than 300 units, it causes an increase in return, the upper and right figure of the relationship between EPU_CHINA and the market It shows the Iranian stock market, according to the figure, there is a nonlinear relationship for values up to about 300 units, the relationship is negative, for values between 300 and 600, there is a positive relationship, and after several volatility in other values, for very high values High in EPU_CHINA causes a significant drop in stock market returns.

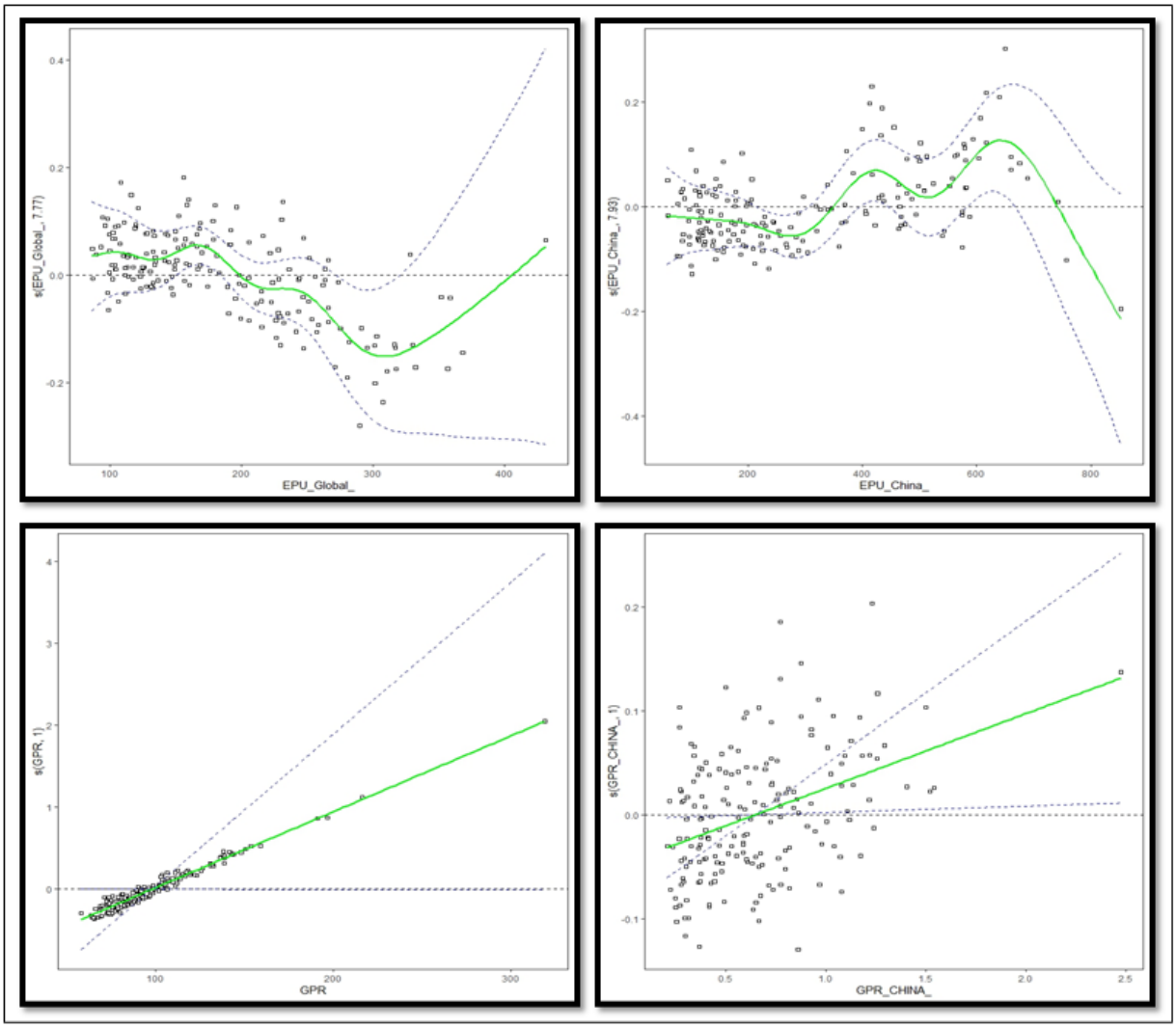

Figure1. Smooth function related to the effects of single variables on the returns of the Iranian stock market

The two figures below show the relationship between GPR of global origin and GPR of Chinese origin on the return of the Iranian stock market; the findings show that the uncertainty of GPR with global and Chinese origin increases the return of the Iranian stock market, this relationship It is linear, in other words, the results show that if there is uncertainty in the geopolitical sphere, Iranian investors perceive the Iranian stock exchange as a safe asset, there is no significant relationship between the EPU and the origin of the United States. GPR with the origin of the United States on the return of the Iranian stock exchange, shows that, from the point of view of investments, the occurrence of each of the factors individually will not have an impact on the economy of Iran.

In the following, the smooth function related to the simultaneous effects of uncertainties with global origin on the return of the Iranian stock market is presented in Figure 2:

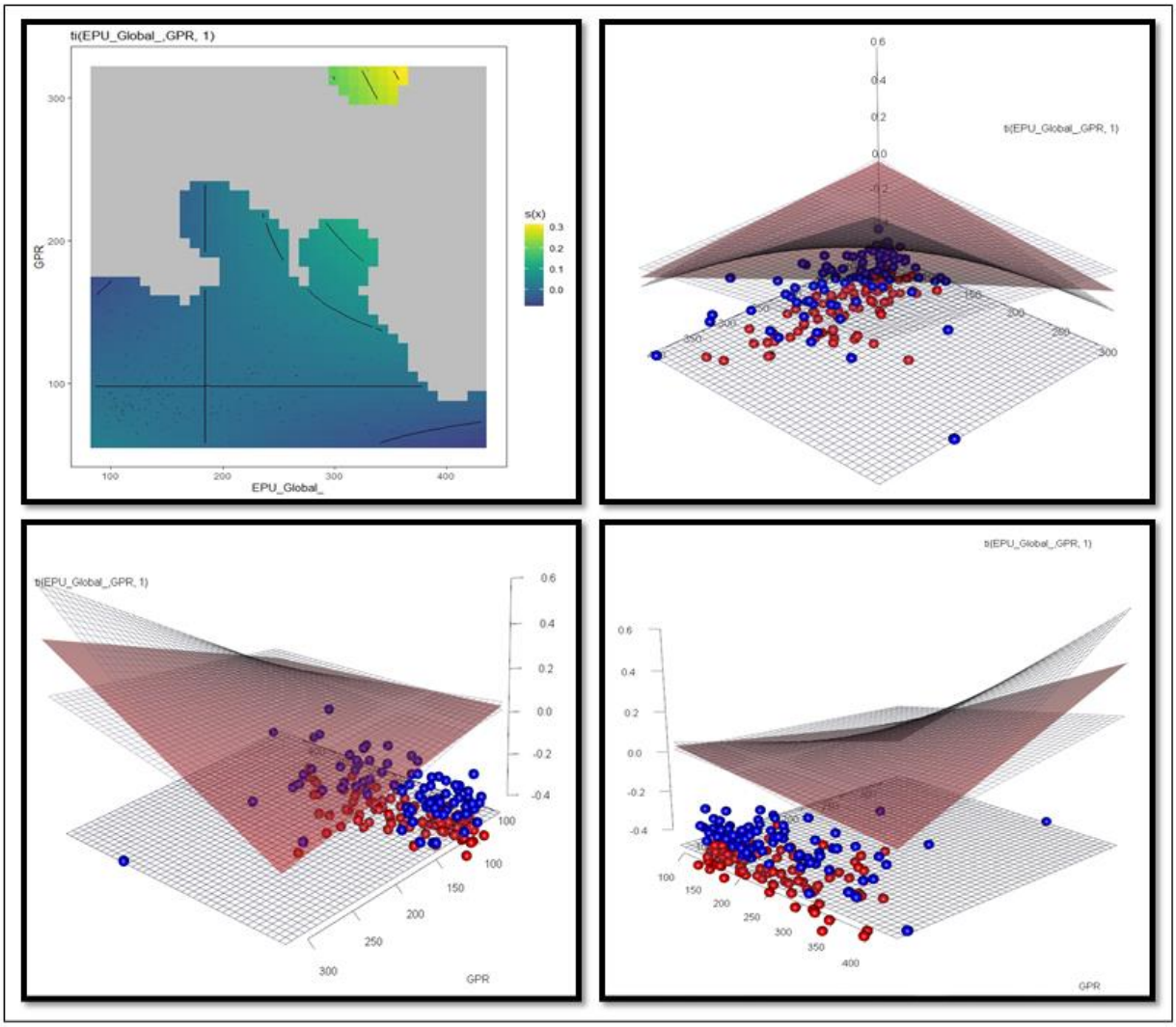

Figure 2. Smooth function related to the effects of simultaneous variables with global origin on the returns of the Iranian stock market

According to Figure 2, in the upper right image, EPU_Global is shown on the horizontal axis, GPR on the vertical axis, and the influence of the return of the Iranian stock market on the third axis. The parts shown in light color are the sets that have a historical record, the parts marked with muted color (gray) show the sets that do not have a historical record (such pairs as Figure. have not been taken), the other three images show the effectiveness of the return of the Iranian stock market (according to the GAM methodology for all the sets that have been formed and the sets that do not have historical data with this combination), the findings It shows that the simultaneous increase in EPU_Global and GPR causes a significant increase in the return of the Iranian stock market. The increase of each of the uncertainties, in a situation where other uncertainties do not occur, reduces the efficiency of the Iranian stock market.

Figure 3 shows the effectivity of the Iranian stock market's return on China's uncertainties.

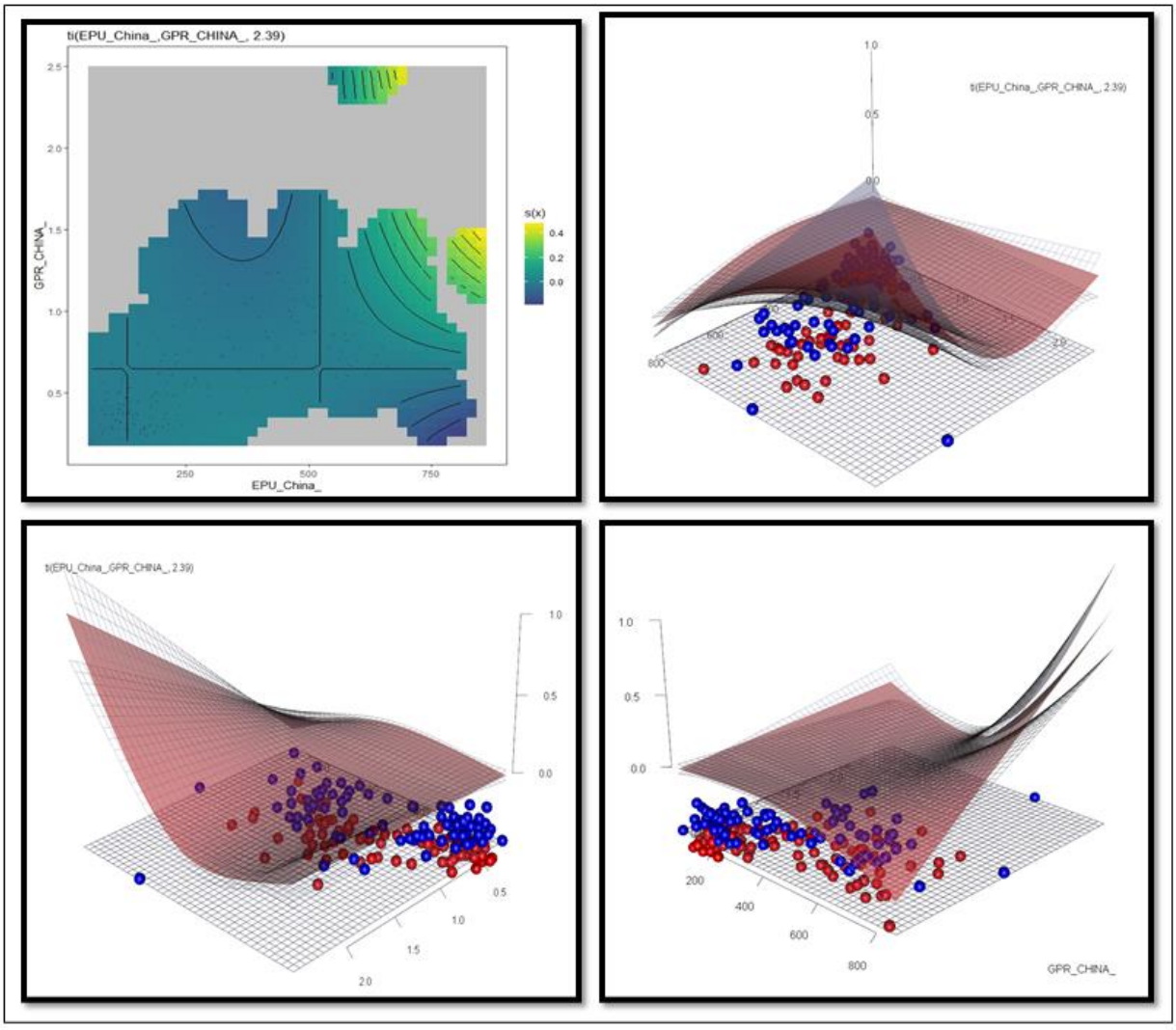

Figure 3. Smooth function related to the effects of the simultaneous variable with the origin of China on the return of the Iranian stock market

According to Figure 3, the simultaneous increase in EPU_CHINA and GPR_CHINA causes a significant increase in the return of the Iranian stock market, and the increase in EPU_CHINA in small amounts of GPR_CHINA causes a drop in the return of the Iranian stock market. An increase in EPU_CHINA at small values of GPR_CHINA increases the return .The rest of the compounds in the values of two uncertainties with the origin of China and the effects on the return are shown in Figure 3.

Figure 4 shows the influence of the Iranian stock market returns on the uncertainties of the United States.

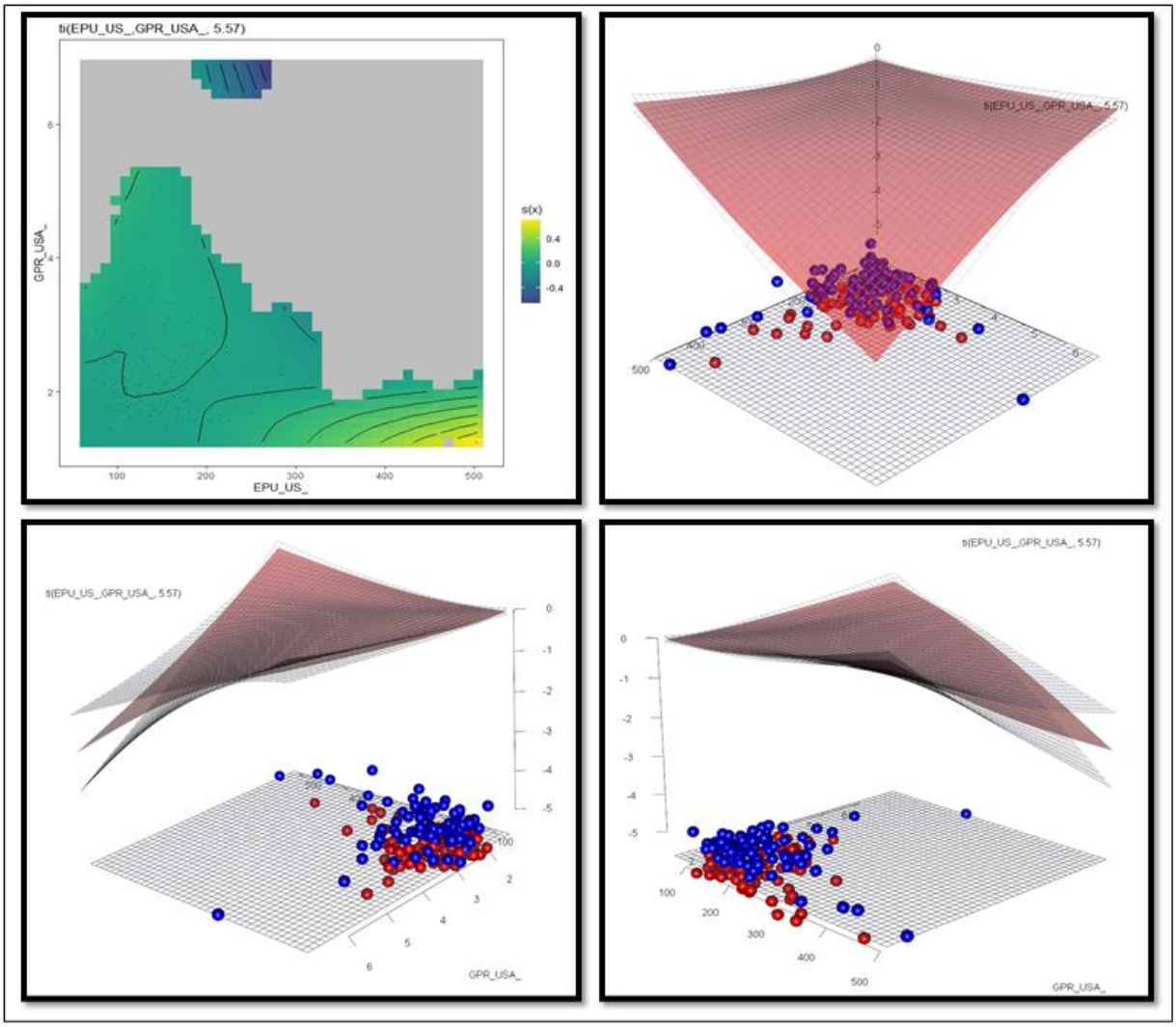

Figure 4. Smooth function related to the simultaneous variable effects of the country of origin of the United States on the returns of the Iranian stock market

According to Figure 4, the simultaneous increase in EPU_USA and GPR_USA causes a decrease in the return of the Iranian stock market, an increase in each of the uncertainties with the origin of the United States, in the condition that the other uncertainty is insignificant, does not affect the return of the Iranian stock market, but binary combinations of the uncertainties of the United States reduce the return of the Iranian stock market.

By putting together the results of the simultaneous effects with the global origin, China and the United States, it shows that the simultaneous increase in EPU and GPR with the origins of China and the United States increases the return of the Iranian stock market. Still, the simultaneous increase In the uncertainties with the origin of the United States causes the return to fall.

At the same time, the United States is the largest economy on the planet and has about one-fifth of global production, energy demand, foreign direct investment (FDI), one-tenth of global trade and one-third of the stock market value, but comparing the sources of risk in the United States, China and Global, shows that the reaction of Iran's stock market returns to global and Chinese origins is

exactly the same and is in contrast to the results of the United States, this finding can be justified considering the political tensions between Iran and the United States.

In general, the occurrence of uncertainties in China and globally encourages investors to increase capital in the financial markets; this behavior can be argued for several reasons:

First, it may be perceived that uncertainties enter Iran's economy; therefore, by investing in the financial market as a safe asset, they seek to preserve the value of money.

Secondly, the occurrence of uncertainty in Iran's commercial parties and comparing it with Iran's conditions will signal to investors that the relative performance of Iran's economy has increased and they will increase the amount of investment in the stock market.

4.3 Robustness check (The impact of uncertainties on the monthly volatility of the Iranian stock market)

According to Table (6) (presented in the appendix), the estimation results show that the effect of EPU with all three origins (global, China and the United States) on the volatility of the Iranian stock market is significant. Also, the impact of GPR with global origin and China is significant; the GPR of the United States, similar to the results obtained in model 1, does not have a significant effect on the volatility of the Iranian stock market; also, the effects of GPR are linear like the results of model 1, in the effects related to simultaneous uncertainties with a fixed origin, simultaneous uncertainty with a global origin does not affect volatility, the effect of simultaneous uncertainties with the origin of China is significant and is linear and the effect of simultaneous uncertainties with the origin of the United States is significant and nonlinear.

Examining the Smooth function related to the single variables according to Figure 5 (provided in the appendix) shows that the EPU with the global origin and the United States country causes a decrease in volatility. In contrast, the EPU, which originated in China, causes an increase in volatility. The relationship between GPR with global origin and China is positive and linear, similar to the effect on returns.

Examining the Smooth function related to the simultaneous variables, according to Figure 6 and Figure 7 (provided in the appendix), shows that the simultaneous increase in uncertainties with the origin of China causes an increase in volatility, but the simultaneous increase in uncertainties with the origin of the country The United States reduces the volatility of the Iranian stock market.

5. Conclusion

This research tested the effects of two types of uncertainty (EPU and GPR) with three global origins, China and the United States, on the returns and volatility of the Iranian stock market.

The results show that EPU_Global and EPU_CHINA significantly affect the return of the Iranian stock market; this effect is nonlinear and is negative for the initial values and then positive. These findings in terms of reducing returns are in accordance with the findings of **(**Das and Kumar, 2018**;** Hu et al., 2018**;** Kido, 2018**;** Liang et al., 2020**),** but the findings of this research show that the relationship is only within a certain range and from then on the relationship The form is positive and significant, therefore, in terms of examining the relationship with respect to different uncertainty values, this article is innovative. Also, the results show that EPU_US has no significant effect on the performance of the Iranian stock market; this finding shows a relationship. A

meaningful relationship between the economies of the two countries is one of the requirements to be affected by the EPU of that country.

In terms of examining the effects of GPR on the return of the Iranian stock exchange, the results show that the GPR with its global and Chinese origin increases the return of the Iranian stock market, this finding is in contrast with the results of the studies of Arfaoui and Naoui (2022) and Rawat and Arif (2018) and are consistent with the findings of Ramiah et al. (2010) and Cam (2008), the argument of Cam (2008) is that GPR increases the demand for weapons, ammunition, some food, etc., and in this sense, the stocks of those sectors may have increased returns, The argument of Ramiah et al. (2010) also states that capital market activists may not understand the impact of GPR and it does not cause changes in returns, but the results of studies related to Iran show a new theory, with the occurrence of GPR investors in the Iranian stock market, This market is considered as a safe asset and the occurrence of GPR is considered as an incentive to enter the capital market in Iran, the origin of GPR is also important, GPR is related to countries with which Iran's economy has serious interactions.

Examining the simultaneous effects in this research shows that in response to two simultaneous events, investors show behavior that cannot be calculated by comparing their individual effects, for example, the effect of GPR and EPU of the United States individually on the return of the Iranian stock exchange is not significant, but the simultaneous effect of these two causes a decrease in return.

The effects of the mentioned variables on the fluctuations of the Iranian stock exchange have also been investigated; in examining the effects of EPU with different origins, the results show that EPU with Chinese origin causes a significant increase in volatility, but EPU with global and US origin causes a decrease in volatility. Past studies show that EPU increases volatility; studies such as Su et al. (2019) and Dakhlaoui and Aloui (2016), it can be argued that EPU can affect volatility in two ways:

1- It causes a sudden shock and actually the investors enter the "sit and watch" mode.

2- They cause quick decisions to be made.

By comparing the argument presented with the findings, it can be said that seeing China's EPU by investors will mean the occurrence of a series of specific effects on the economy, so they start to change their portfolio, but seeing EPU with the origin of the United States and Globally, it is not recognizable for investors, so they prefer not to take action.

Investigating the effects of GPR on the volatility of the Iranian stock market shows that GPR with Chinese and global origin increases volatility; this finding is in line with the findings of the studies of Salisu et al. (2022), Ndako et al. (2021), Chiang (2021) and Zhang et al. (2023) is consistent, also the GPR with the origin of the United States has no effect on the volatility of the Iranian stock market, this finding is in contrast with the mentioned studies and consistent with the result of the study of Bouras et al. (2019).

The results of this research are useful for investors and financial market participants; it also shows a new point of view on the necessity of examining the variables; at the same time, it also shows that the level of commercial and political communication has a significant role on the influence of financial markets, for future studies it is suggested that the text mining indicators related to GPR and EPU for The country of Iran should be extracted and then their effects on the return and volatility of the financial market of Iran should be investigated.

6. Appendix

Table 6. Estimation results of the model2; SE stands for the standard error of the parameter estimate. ‘‘edf’’ represents the effective degrees of freedom of the functional parameters and Ref. df is the Reference degrees of freedom

Parametric coefficients					
	Estimate	**SE**	**t value**	**p-value**	
(Intercept)	0.04180	0.00715	5.841	0.00	***
Approximate significance of smooth terms					
	edf	**Ref.df**	**F**	**p-value**	
s(EPU_Global_)	4.211	5.337	2.072	0.08	.
s(EPU_China_)	6.990	8.029	3.087	0.00	**
s(EPU_US_)	6.260	7.414	1.763	0.08	.
s(GPR)	1.000	1.000	4.403	0.03	*
s(GPR_CHINA_)	1.000	1.000	2.871	0.09	.
s(GPR_USA_)	1.000	1.000	1.065	0.30	
ti(EPU_Global_,GPR)	1.000	1.000	0.828	0.36	
ti(EPU_China_,GPR_CHINA_)	1.000	1.000	3.333	0.07	.
ti(EPU_US_,GPR_USA_)	10.867	11.875	3.245	0.00	***
Signif. codes: 0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1					
R-sq.(adj)	0.648		Deviance explained	74.7%	

Source: research calculations

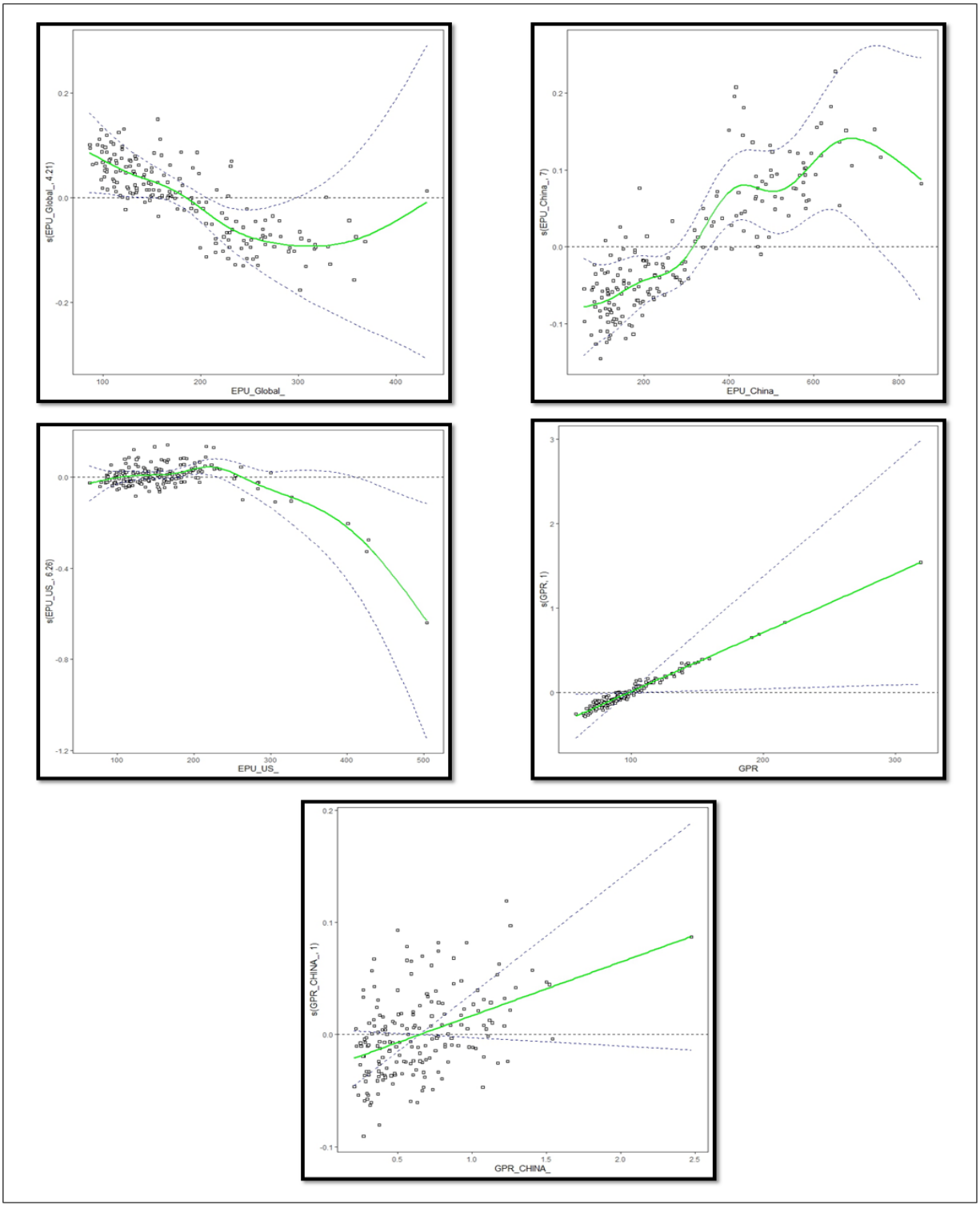

Figure 5. Smooth function related to the effects of single variables on the volatility of the Iranian stock market

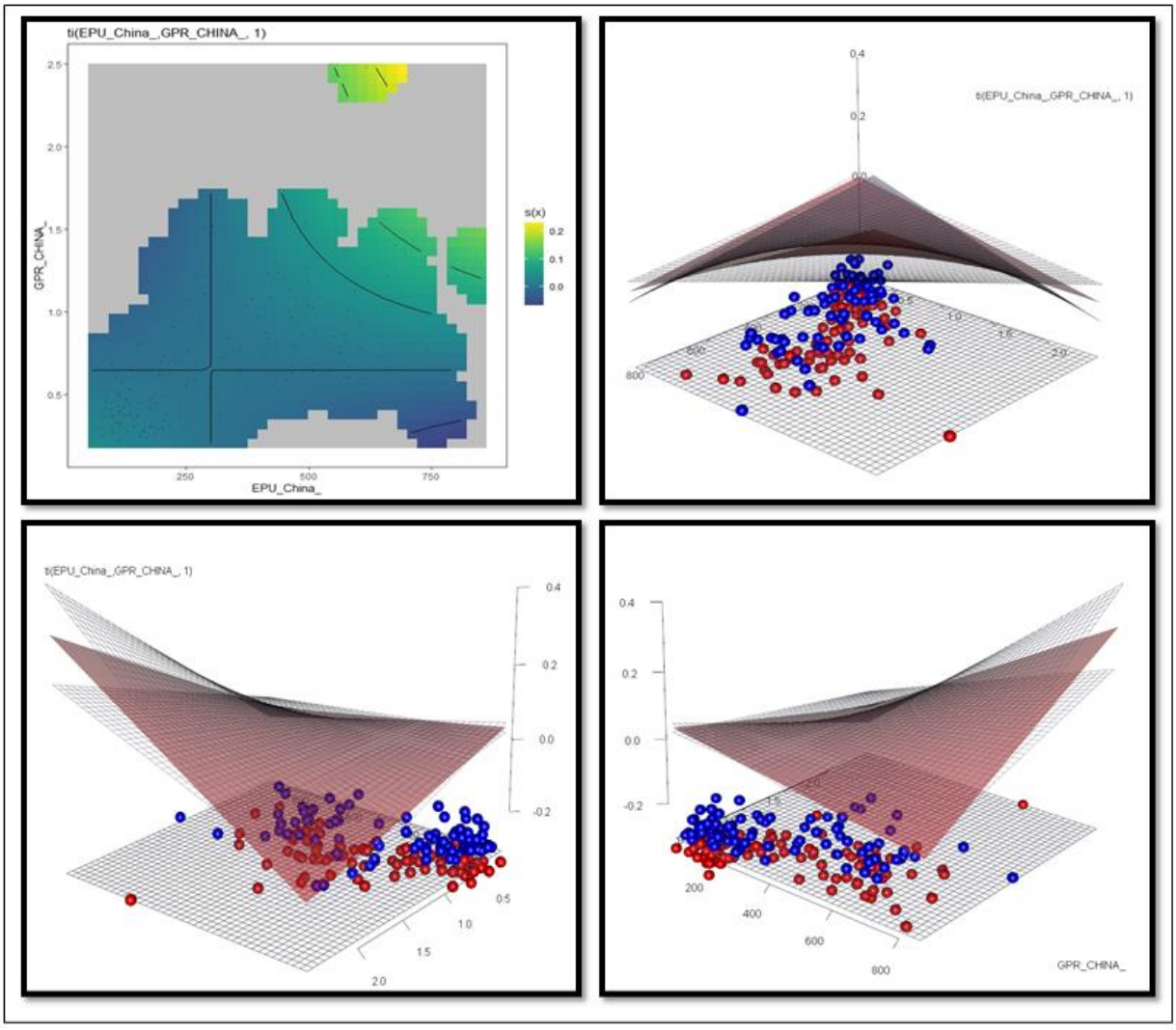

Figure 6. Smooth function related to the effects of the simultaneous variable with the origin of China on the volatility of the Iranian stock market

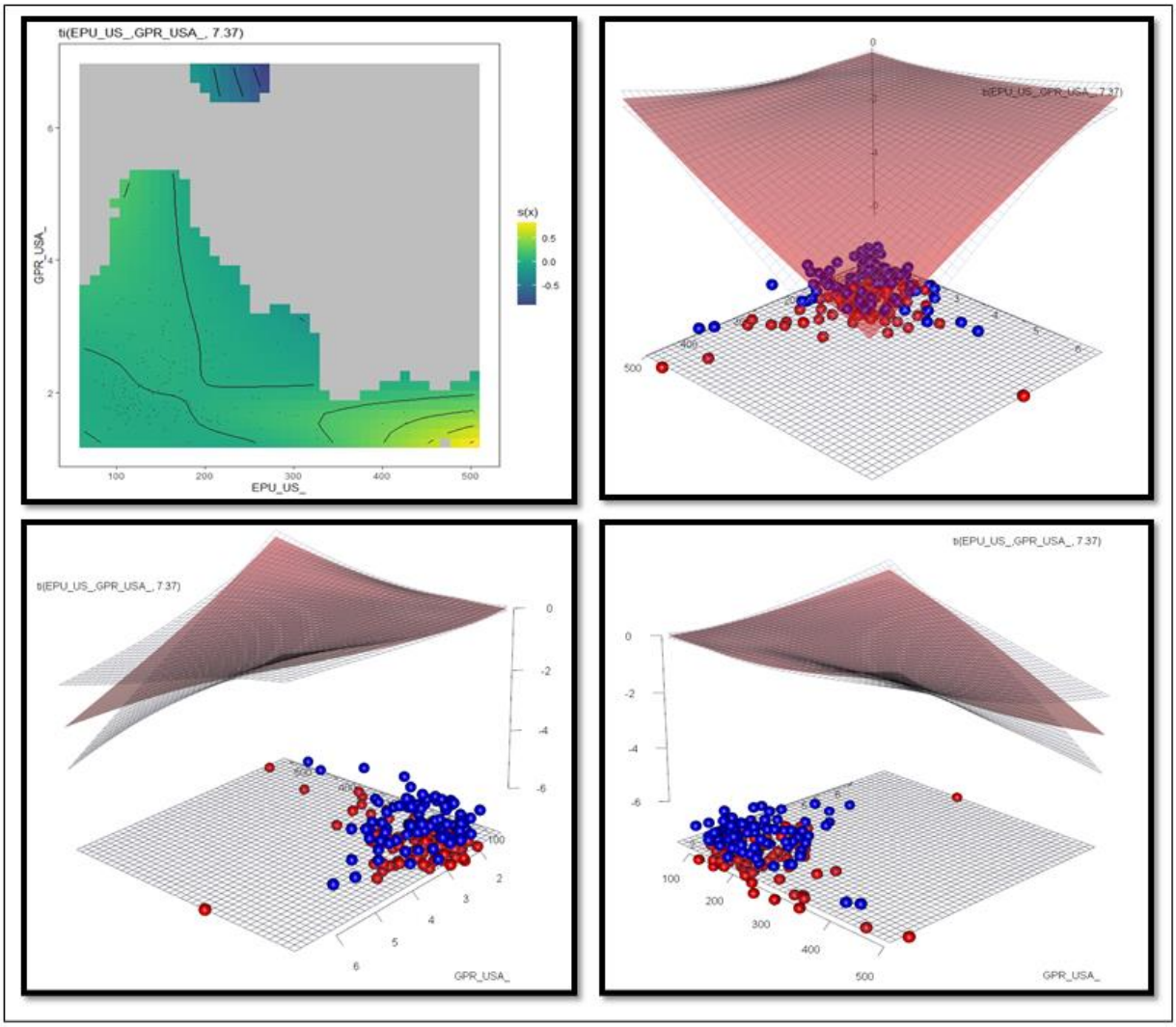

Figure 7. Smooth function related to the simultaneous variable effects of the country of origin of the United States on the volatility of the Iranian stock market

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